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OBSERVATIONS ON THE NATURAL HISTORY OF DIVING BEETLES

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OUR predacious diving beetles of the family Dytiscidæ are fairly well known as museum species, but the study of their life histories and habits has been singularly neglected. A number of our genera and a few of our species occur also in Europe, and the natural history of some of these has been studied there; but practically nothing has been done in this line in our own country. Therefore the following observations on the habits and adaptations of the group may serve to direct attention to an unworked but interesting field.

Dytiscidæ are very common at Lake Forest, and are very accessible in a campus pond that lies almost under the windows of the biological laboratory. They illustrate very well the more obvious phenomena of adaptation, and have been much used by the senior author for that purpose with classes for a number of years. The material incidentally accumulated in that work, combined with special studies of life histories and habits made by the junior author during the academic year 1905–6, will constitute this paper.

The campus pond (locally known as the "Gym Pond") from which our material has mainly been obtained, is an artificial one, made by damming a short, spring-fed branch of one of the ravines that bound the campus. It has been in existence for many years, and conditions in it are now quite natural. It is some sixty meters long and about half as wide, and it attains a depth of four and a half meters in its deepest part, near the dam. Toward the other end it becomes shallow, and is filled with a dense and clear growth of cat-tails (Typha). There is very little other vegetation in it anywhere, but the hollows of its shores become filled in autumn with oak leaves from the surrounding forest trees.

It is in the typha beds of the upper end of the pond, extending from the shore outward into water of about a meter in depth, that the diving beetles are commonly found. These beds cover an area of but little more than a square decameter, but in them we have found twenty-nine species of Dytiscidæ, as follows,—

*_Laccophilus maculosus_ Germar
Laccophilus fasciatus Aubé
Laccophilus proximus Say
Hydrovatus cuspidatus Germar
*_Bidessus lacustris_ Say
Bidessus flavicollis Lec.
Bidessus affinis Say
*_Cœlambus inequalis_ Fabr.
Cœlambus punctatus Say
Cœlambus dispar
Cœlambus acaroides Lec.
Cœlambus nubilus Lec.
Cœlambus impresso-punctatus Sch.
Deronectes catascopium Say
*_Hydroporus undulatus_ Say
Hydroporus modestus Aubé
Hydroporus dichrous Melsh.
Ilybius confusus Aubé
*_Coptotomus interrogatus_ Say
Agabus subfuscatus Sharp
Agabus disintegratus Cr.
Rhantus notatus Fabr.
Colymbetes sculptilis Harr.
Hydaticus piceus Lec.
*_Acilius semisulcatus_ Aubé
Acilius fraternus Harr.
*_Dytiscus hybridus_ Aubé
Thermonectes basilaris Harr.
Graphoderes cinereus Linn.

No other Dytiscidæ have been found at Lake Forest, except two that are occasionally cast up on the beach of Lake Michigan and that we have picked up from the drift line,— _Agabus semipunctatus_ Kirby and _Cybister fimbriolatus_ Say.

Distribution by Size and Depth of Water.— The seven species of the above list that are marked with a * are very common and easily obtained; and being fairly representative of the family, these were made the basis for the observations which follow. These fairly represent the striking difference in size that is found in this family coupled with an almost unparalleled uniformity of shape (Fig. 1.)

The shoreward distribution of these beetles corresponds roughly with their size: the largest are found in the deepest water, the smallest nearest shore. Dytiscus is usually found in the more open places between the outposts of the typha beds in the deepest water, and Acilius is adjacent to it on the shoreward side, although both (as well as the following species) may range shoreward foraging. Coptotomus abounds in water about a third of a meter in depth, and loves to disport itself in the narrow aisles between the typha clumps. Laccophilus dwells amid the fallen stems and trashy accumulations nearer shore, and is less in evidence in open water. Hydroporus and Cœlambus love the shoals into which one can look down while sitting on the bank, while Bidessus clings to the very shore line: it has nearly always been found by us within a few inches of dry land.

The larvæ of these forms show, likewise, a general distribution in depth corresponding to their size although the larvæ keep more closely to cover of vegetation than do the adults. Dytiscus larvæ are found chiefly in the more open vegetation in the deeper water: Bidessus larvæ, at the shore line: and the others ranged between. It must not be understood that there is any such definite and sharply limited zonal distribution as aquatic plants on such a sloping shore often exhibit: that is not to be expected in animals possessed of such excellent powers of locomotion: we have meant to indicate merely the favorite haunts of each species, and the general correspondence between size of beetle and depth of water.

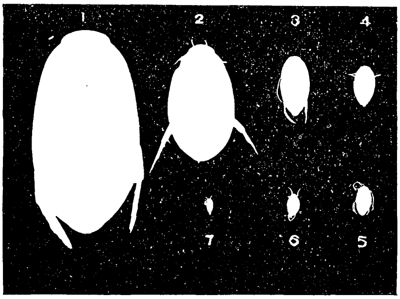

FIG. 1.— Silhouette print of seven adult diving beetles, illustrating the uniformity of shape and disparity of size found in the family Dytiscidæ: natural size. 1, *Dytiscus hybridus* Aubé. 2, *Acilius semisulcatus* Aubé. 3, *Coptotomus interrogatus* Fabr. 4, *Laccophilus maculosus* Germ. 5, *Hydroporus undulatus* Say. 6, *Cœlambus inequalis* Fabr. 7, *Bidessus lacustris* Say.

The accompanying table gives a more precise statement of the difference in size of the seven common forms of adult beetles already mentioned. The length was measured with a metric caliper rule. Weight was determined with a chemical balance. Live beetles were weighed inclosed in envelopes of absorbent paper to remove the excess of moisture; then the weight of the paper with its contained water was deducted, and the remainder was divided by the number of the beetles used. By this means fairly accurate average weights were secured. In the other columns of the table are expressed with much less accuracy the comparative excellence of these seven beetles with respect to their different modes of locomotion.

			Order of excellence in		
Name	Length	Weight	Swimming	Walking	Jumping
Dytiscus hybridus	27.6 mm.	1.303 grams	1	7	5
Acilius semisulcatus	14.1	.1936	2	6	2
Coptotomus interrogatus	7.9	.033	3	5	3
Laccophilus maculosus	5.5	.0142	4	4	1
Hydroporus undulatus	4.0	.010	5	3	4
Coelambus nubilus	2.9	.0032	6	2	6
Bidessus lacustris	2.0	.0005	7	1	*

The Activities of the Adult Beetles. — There is a very marked difference in the swimming powers of these beetles. Such forms as Cybister probably manifest the highest efficiency in the family. The long beautifully fringed hind legs are moved synchronously; the flattened and fringed tarsi and the blade-like lower tibial spur meet the water squarely, and each stroke sends the body forward several times its own length; whereas the rapid strokes of the scantily fringed feet of some of the lower members of the family, little modified in their motion from that employed in walking, produce individually but little result in forward progress. In arriving at an estimate of the swimming capacity of the seven forms listed in the above table the actual distance traversed per second was determined, and also the distance for each stroke of the swimming legs. In order to make just allowance for differences of size, this distance was expressed in terms of length of body. There was some difficulty in making these measurements, owing to the extreme rapidity of movement of the legs in the case of some of the smaller beetles, and owing also to the irregularity of their movements. In general, the ability to hold a straight course, to control equilibrium in turning, and to economize effort by elimination of useless motions of the fore legs was also taken into account and the estimated average is expressed in the table. Beetles fresh from the pond were used in every case.

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* Could not be induced to jump at all.

Walking was compared by turning the beetles out upon a long sheet of blotting paper before a window, and allowing them to run toward the light. Excellence at walking was estimated not so much by speed as by ability to support and propel the body upon all of the feet. The greatest speed across the paper was occasionally attained by Dytiscus but it was not walking: it slid along on its belly, with its hind feet high in air, its front feet reaching forward, catching the hooked claws and drawing the body after. Bidessus, however, gets up on its feet and runs like a ground beetle, freely using all its tarsi. There is in Bidessus none of that flopping and floundering that characterizes the progression of the more specialized forms when out of water.

Jumping, in this table, covers any sort of sudden springing forward in air. The hind feet alone may be used very effectively, as in Laccophilus which is by far the best jumper of the lot, but they may also be assisted by the wings. It is not an uncommon thing to see at the pond a Laccophilus suddenly emerge from some trash floating on the surface and instantly spring into the air, using its wings as well as its legs, and then drop on the water and disappear instantly beneath it: for Laccophilus can take flight very quickly. The slow and lumbering start of most members of the family, is not at all characteristic of this beetle. The superior jumping powers of Laccophilus are explained in large part by the structure of its legs; especially their equipment of tarsal spines (Fig. 2 *A*).

The order of excellence in swimming and walking in this series of beetles has been determined by classes of students at Lake Forest for a number of years, and it has always been found as it stands in our table. The suspicious regularity of the figures raised some doubts in our minds as to their correctness: so the junior author went over the work of determining them carefully anew, with the result that they appear to be entirely confirmed. Doubtless such close correlation between size and excellence of swimming would not hold everywhere among the Dytiscidæ. Some of the smaller, more convex forms are very highly specialized. Our series of seven selected at first solely on account of availability and abundance happened to be a most excellent one for illustrating the law of specialization. Nothing could be clearer than that, in this series, increasing fitness for locomotion in water accompanies increasing unfitness for locomotion on land.

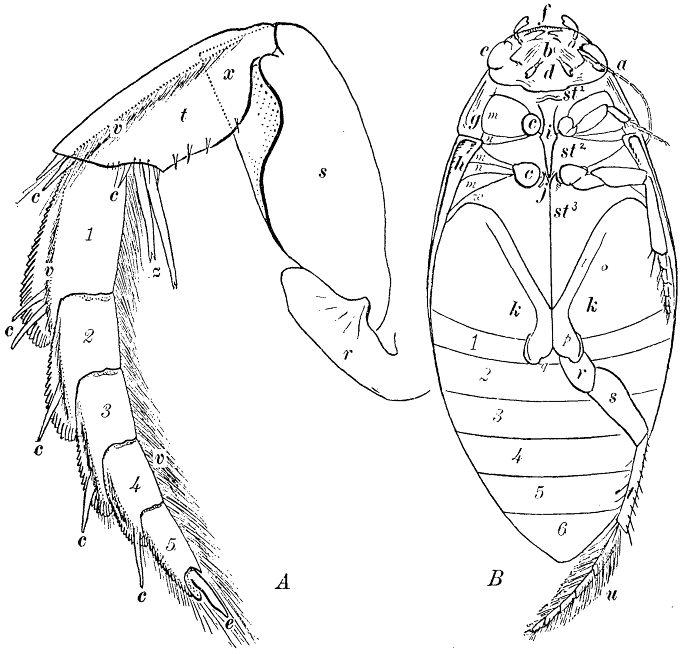

FIG. 2.— *A*, Ventral view of the hind leg of *Laccophilus maculosus*. *r*, trochanter. *s*, femur, and *x*, its prolonged posterior angle. *t*, tibia, and *z*, its spurs. *1*, *2*, *3*, *4*, *5*, tarsal segments. *e*, the single rudimentary claw. *v*, *v*, *v*, swimming fringes. *c*, *c*, *c*, *c*, *c*, *c*, jumping spines.

B, Ventral view of *Coptotomus interrogatus*. *a*, antenna. *b*, mouth. *c*, *c*, fore and middle coxal cavities. *d*, labial palpi. *e*, eye. *f*, maxillary palpi. *g*, lateral margin of pronotum. *h*, epipleuron. *i*, prosternal process. *j*, bifurcated intercoxal process of the metasternum in which is lodged the anterior end of the mid-ventral metasternal groove. *k*, *k*, hind coxæ; *l*, inner and *o*, outer laminæ of same. *m*, *m*, *m*, epistema of the three thoracic segments. *n*, *n*, epimera of prothorax and mesothorax. *p*, the coxal process, and *q*, the coxal notch in the right coxal process. *r*, trochanter. *s*, femur. *st*¹, *st*², *st*³, sterna of the prosternum, mesosternum, and metasternum respectively. *t*, tibia. *u*, tarsus. *w*, wing of the metasternum. *1*, *2*, *3*, *4*, *5*, *6*, ventral abdominal segments.

The Structural Adaptations of the Beetles for Aquatic Life.— The ancestors of the Dytiscidæ were doubtless terrestrial, and probably they were not very different from ground beetles of the family Carabidæ. Coleopterists agree that the association between these two families is a very close one. If we compare any ground beetle (as, for example, Calosoma) with any of the higher Dytiscidæ (such as Dytiscus) we shall see some marked contrasts in appearance, and some indications of the main lines that have been followed in the adaptation of the latter to aquatic life. The body of Calosoma is loosely jointed; its surface is provided with sensory hairs and is sculptured; its antennæ are prominent and hairy, and its feet are long and adjustable to every inequality of its path. Dytiscus on the contrary is compact of body and evenly contoured, pointed at both ends and naked, with slender hairless reversible antennæ, and stiff oar-like hind feet. There are three main features of this adaptation, namely an increased rigidity of the body, diminished resistance to the water, and an increased swimming efficiency of the hind legs.

The increase in the rigidty of the body has been accomplished by the compacting and coadaptation of the parts of the external skeleton. Close conjunction has been effected between the head and prothorax (through immersion of the head into the front of the latter); between the several segments of the thorax; between the elytra and the sides of the abdomen; between the front margin of the elytra and the prothorax; and between the two elytra along the dorsal suture: this and the joining with the sides of the abdomen combine to make the air chamber inclosed beneath the elytra water tight. These coadaptations which distinguish the Dytiscidæ from terrestrial Coleoptera have been well recognized by systematists, and are especially well discussed in Sharp's great monograph of the family Dytiscidæ.[1] Rigidity is demanded in the body of a diving beetle as in the hull of a boat. The means of securing it are most noteworthy in those parts where in other beetles we find great flexibility, as between the first two segments of the thorax. This particular articulation can be fully seen and appreciated only in a disarticulated beetle, some of the coadaptive structures being more or less concealed by parts external to them. It is technically described by Dr. Sharp (*l. c.* p. 219) as follows:

> "The coadaptation of the various parts of the posterior aspect of the prothorax, to corresponding parts of the after-body and base of the wing cases is extremely perfect and very complicated; proceeding from below upward, we have first, the prosternal process (Fig. 2 *B, i*) stretching beyond the meso-

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[1] On Aquatic Carnivorous Coleoptera or Dytiscidæ. *Trans. Roy. Dublin Soc.* for 1882.

sternum to be received in a metasternal groove; directly above the prosternal process we see a considerable protuberance or prominence which fits into the fork of the mesosternum; then come the posterior aspects of the coxæ, which fit into facets on the face of the mesosternum, and on a still higher level we have the transverse bridge closing the coxal cavities which fits into the interior of the mesosternum, while on the upper surface we find that the base of the mesothorax and scutellum are shaped so as to allow the hind margin of the pronotum to overlap and accurately fit them, while the shoulders of the wing cases are prominent, and rest on an expansion of the posterior face of the pronotum which is beautifully sinuate and emarginate to facilitate the coadaptation. This joining is so perfect in the higher forms, such as Cybister, that if after the prothorax has been detached from the after-body an attempt be made to replace it in its natural position, this is very easily effected; and it will then be found that the prothorax retains its position in spite of considerable efforts being made to dislodge it."

A diminished resistance to the water has been brought about in many ways,[1] notably by the rounding of the contours of the body especially at the neck and shoulders, so that it assumes a boat shaped form†; by the depression of the eyes†; by the loss of hair† and sculpture; by reversal of the antennæ; by recession of the fore and middle legs into the concavities beneath the thorax at the sides; and by the flattening of the hind legs in the horizontal plane†.

The increased swimming efficiency of the hind legs has also been brought about in many ways, the seven most striking of which are as follows,— the flattening down and soldering fast of the hind coxæ (Fig. 2 *B*, *k k*) to the ventral surface of the metasternum, transforming what is in other beetles a movable joint into a remarkably rigid supporting base; the bringing of the basal joints of the leg into one plane of action, limiting their movements, but increasing the range of motion in the one horizontal plane; the development of braces at the joints to further limit motion to one plane, making the leg more rigid and oar-like; the shortening of the proximal joints of the leg †; the lengthening of the joints of the tarsus† accompanied by the flattening of these joints and occasionally of the tibial spurs as well; the development of swimming fringes in the thin lateral margins of the tarsus; the recurvature of the tarsi to a more dorsal position, in line with the motion of the center of gravity of the body †; and finally the loss of the hind claws†.

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[1] The features designated by a dagger in this and the following paragraph appear to be exact parallels of aquatic adaptations in mammals, as stated in Dr. Osburn's interesting article in the *American Naturalist* for October, 1903 (vol. 37, pp. 651–665). In many other respects it appears that by diverse means analogous results have been attained. That the changes in body are not more directly comparable in the two groups is due to the very great differences in the nature of the supporting skeleton.

The modifications having to do with the taking and storage of air are much less obvious. They consist in the adjustments of the margins of the elytra (already mentioned for their compacting and strengthening function) which tend to make a water tight air-compartment; and in the slight modification of the tracheal system in a few members of the family (Dytiscus, etc.) manifest in the enlargement of the hindmost abdominal spiracles to several times the diameter of the other spiracles. The respiratory apparatus of terrestrial beetles has been evidently fairly adequate, and the main problem has been that of getting through the water with sufficient ease and speed to capture prey and to escape from enemies.

The Larvæ Studied.— Five species of larvæ of Dytiscidæ were kept under observation. Unfortunately but one of these (*Hydroporus undulatus* Say) was reared to the adult beetle. The others are here named tentatively, it being possible to make a supposition as to the genera to which they belong, based on the known fauna of the Gym pond, on their size, and on their likeness to known European forms. The largest larvæ encountered (41 mm. long) were those of Dytiscus. These are of the sinuous spindle-shaped form, well known from being figured in every entomological text book. We found them in May in great numbers, feeding on Corethra pupæ in the deep narrow straits of open water between standing aquatics, but they are so well known and they require such quantities of live food daily, that we did not attempt to rear them. Of still more snaky form and with an equally good development of swimming fringes on legs and the sides of terminal abdominal segments is the agile larva of Acilius. It is an exceedingly graceful creature, and has a remarkable capacity for dodging quickly when approached. Our specimens of this form were young (15.5 mm. long) and their nurture had to be abandoned before any of them had transformed.

The larvæ which we have referred tentatively to *Coptotomus interrogatus* (Fig. 3) are but poorly adapted for aquatic life: they are much more like primitive ground beetle larvæ of the family

Carabidæ. We obtained numerous specimens in the fall of 1905 when our cages were first started, and these furnished our early experience. The first lot collected, kept over night in a small vessel, ate each other; in the morning but one remained. The second lot, kept over night in a large vessel with plenty of proper food, did exactly the same. Then we made a screen cage with separate compartments, set it in an aquarium and put our third lot into it, one larva in each compartment. These then climbed out of the water and over the partitions and ate each other as the others had done. They did not mind a little ramble in the open air at all. By this time we had learned the necessity of covering the top as well as the bottom of each compartment: but unfortunately we were not then able to find any more larvæ. This is the more regrettable because no larvæ in this endemic American genus have been made known. A description of the larva is appended to this paper.

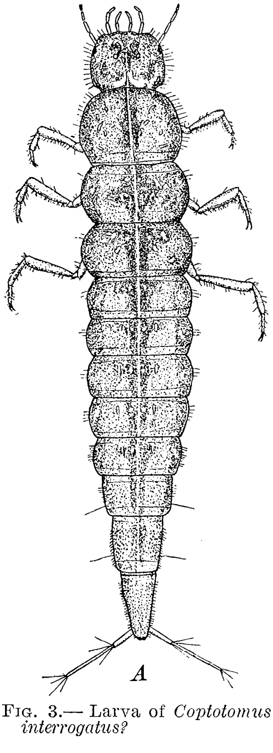

Fig. 3.— Larva of *Coptotomus interrogatus?*

We were fortunate in finding in the spring of 1906 grown larvæ of *Hydroporus undulatus* Say (Fig. 4), and in rearing them. These were taken from the pond May 20th and were kept in shallow water in a flat bottomed white dish containing a few dead leaves and bits of typha stems. Showing nothing of the disposition of the larger larvæ to eat each other, we left them together in the dish and fed them with small fresh pieces of damselfly larvæ. On May 29th four of the larvæ were found inactive and curled up on their backs on the bottom of the dish. These were placed on damp sand in a dish covered so as to be perfectly dark. They did not spin, nor make a cell, nor even move from the positions in which we placed them, but on June 2nd, two of them were found transformed to soft white pupæ of the form shown in Fig. 5 and two days later the other two had transformed. On June 8th, the first one transformed to the adult beetle. A little later adults of the same species could be collected commonly from the edges of the pond.

The minute larvæ of Bidessus, apparently grown, were found so near the close of our work that there was no time for attempting to rear them. They are here referred to the commonest species of the genus from the same habitat, *Bidessus lacustris.*

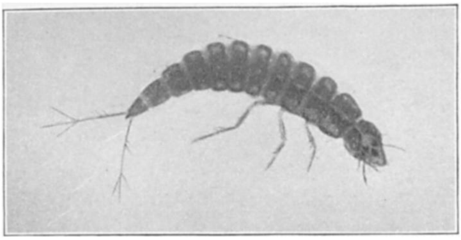

Fig. 4.— Larva of *Hydroporus undulatus.*

Habits of the Larvæ.— The larvæ, like the adults, are all carnivorous. The larger ones are all cannibals: only Hydroporus and Bidessus among those we have taken, when kept together refrain from eating each other. We fed the largest larvæ on damselfly and mayfly nymphs, and those of medium size on Corethra larvæ, these being the most abundant forage available. For all but the smallest species the manner of feeding is much the same. The prey is seized alive by the fore legs and the mandibles are instantly thrust into it deeply, and it is sucked until nothing remains but the empty skin. For the small Hydroporus larvæ we were unable to supply living prey of suitably small size: so, pieces of damselfly larvæ freshly cut up for the purpose, were used. These were seized between the long frontal horn (Fig. 6) and the upcurved mandibles, sucked for a little while, then dropped, to be returned to at intervals and seized and sucked again.

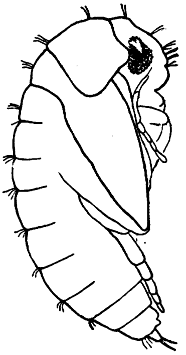

Fig. 5.— Pupa of *Hydroporus undulatus.*

The swimming habits of the different larvæ are remarkably different. Coptotomus (Fig. 3), having little development of swimming fringes, makes very violent and inefficient movements of the legs and abdomen in swimming. When approaching the surface of the water the head is upward and the body advances by a succession of irregular shifts (Fig. 7 *A*, s). It rarely takes a direct course to the surface, and in water of more than a few inches depth, it has great difficulty in reaching the surface by swimming. It can remain below for a considerable time. Of half a dozen specimens transferred to a fresh aquarium and watched, the first to reach the surface came up in about four minutes, but went down again at once: the first to remain at the surface taking air, rose after twelve minutes: several did not rise for at least seventeen minutes. In taking air this species hangs vertically from the surface with legs limply extended, and with caudal cerci outspread upon the surface film (Fig. 7 *A*, *t*). When it leaves the surface, it swims downward head first in an indirect sinuous course. The tail appears not to be used at all as a fin in swimming. The larvæ of Dytiscus are possessed of an excellent swimming fringe along either side of the terminal abdominal segments, and they use their tails continually in swimming, lashing them violently back and forth, up and down. They swim to the surface head upward (Fig. 7 *B*, *v*), but quite as often they float slowly upward with both head and tail elevated, the former a little in advance, and with the body bent in a wide U-shaped curve. Usually when floating thus, bubbles of air may be seen sticking to their bodies. While taking air they retain this curved position (Fig 7 *B*, *w*), the top of the head as well as the caudal cerci resting in the surface film. These larvæ are powerful members of the natural society in which they live, and are much less easily frightened than other species. One of them that had been fed regularly for a few days would allow its back to be stroked gently with a pencil, and not until poked violently would it swim away: then it would

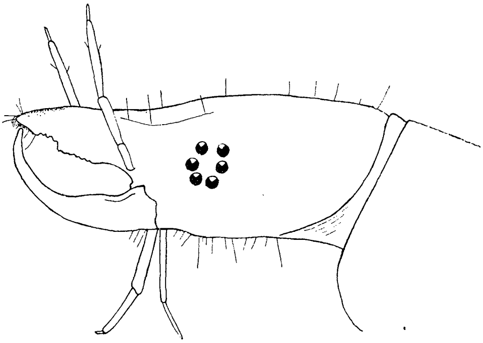
Fig. 6. — Head of larva of *Hydroporus undulatus* seen from the side.

swim very rapidly, as if in sudden alarm, with quick wriggling movements of its body and tail.

The larva of Acilius although much like that of Dytiscus in general appearance and in the possession of excellent swimming fringes, is very different in its habits. It has a peculiar way of swimming toward the surface tail upward, in a sinuous course as indicated in the diagram (Fig. 7 *C*, *x*) its progress being accomplished by very slight movements of its legs. Often one will start from the bottom swimming forward, then circle about horizontally once or twice, and finally rise to the surface, tail upward, as just described. This species swims very rapidly, twisting and turning its long slender body like a snake. When disturbed it darts with a peculiar indescribable motion of the whole body away from the point of disturbance. Sometimes it makes just one quick dodge, and sometimes it goes through a series of wriggling movements so swiftly executed that the eye cannot follow them. This dodging feat must be of great advantage in avoiding enemies.

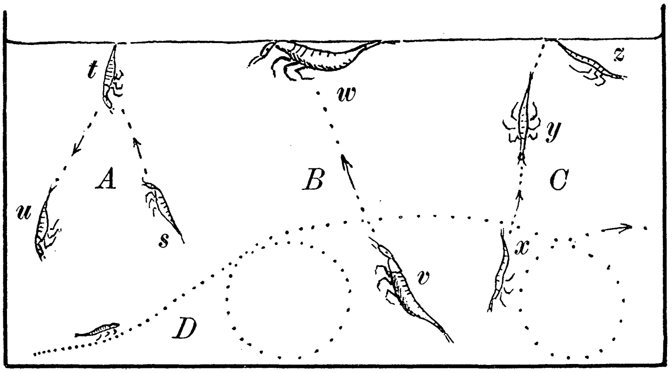

Fig. 7. — Diagram of swimming habits and attitudes of dytiscid larvæ. *A*, *Coptotomus interrogatus* *B*, *Dytiscus hybridus*. *C*, *Acilius sp.?* *D*, *Hydroporus undulatus*.

The larva of Hydroporus (Fig. 4) has only a scanty development of swimming fringes on its legs, and its tail is used merely as a rudder. It crawls much and swims little. It has a boomerang-shaped body, which when projected through the water, has a corresponding motion. It circles about in a vertical plane, its back to the outside of the curve, as indicated in the diagram

(Fig. 7 *D*). Placed in a deep vessel of clear water the Hydroporus larvæ spend much time swimming about in this manner, very rarely rising to the surface. During various periods of observation, none were seen to remain at the surface taking air: and during about an hour and a half of continuous observation of half a dozen specimens together in a large beaker, not one of them rose to the surface. When kept in a shallow dish of water with plant fragments, they spent much time crawling about on the bottom, creeping beneath dead leaves, or hiding in the hollows of the typha stems.

Supplemental descriptions of hitherto unknown larvæ of Dytiscidæ

1. **Coptotomus interrogatus** Fabr. (supposition). Length of larva: 17–18 mm., cerci 2 mm. additional, greatest breadth 2.5–3.0 mm.

Body elongate, rather stout anteriorly: head narrower than the prothorax, which equals the other thoracic and the first four abdominal segments in breadth: terminal segments of the abdomen tapering. General color brown above and on legs; below, paler.

Head depressed, the sides parallel for more than half its length, from the eyes to the spinous margined hind angles, behind which it is constricted to a short neck. Mandibles stout, prominent, channeled nearly to the base (Fig. 8, *g* and *i*). Maxilla with two curved spines upon the inner face (Fig. 8, *a*) in a close fringe of short hairs, a sub-cylindric end segment, a four-jointed palpus and single terminal and dorsal setæ. Labium (Fig. 8, *c*) simple, its body trapezoidal, the anterior margin double-edged and the edges beset with fine short spinules, the second joint of the palpus bearing internally a long fine seta. Antenna (Fig. 8, *d*) four jointed, simple.

The general color of the head above is brown, with a pair of obliquely placed transverse pale marks between the bases of the antennæ; behind these, two small clusters of pale dots with yellow (marks between them and a pair of larger yellow dots behind them. On the occiput, a pair of larger ff. marks more or less confluent with the yellow of the hind margin stands between two more scattered clusters of pale dots, which extend in a line forward and outward to the eyes: outside these lines of dots is a yellow oblique stripe on each side above the spinous margined hind angles.

The prothorax is but little longer than broad, its sides are broadly rounded and its anterior end is constricted to form a short neck. In coloration it is brown above, with a median double row of more or less confluent pale dots abbreviated before and behind and not reaching the ends of the segment, and with a few widely separated, elongate hiero-

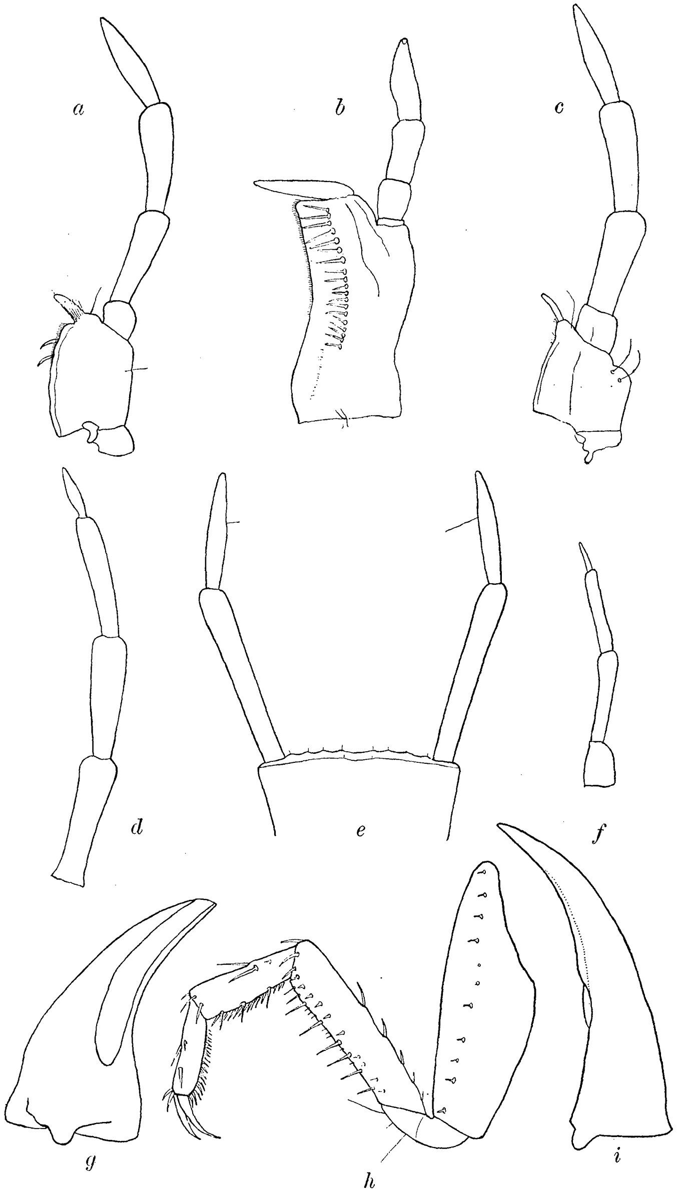

FIG. 8.— Structures of larvæ of Dytiscidæ. *a*, maxilla of *Coptotomus interrogatus* ? *b*, maxilla of *Acilius sp.?* *c*, maxilla of *Coptotomus longulus* ? *d*, antenna and *e*, labium of *Coptotomus interrogatus* ? *f*, maxilla of *Hydroporus undulatus*. *g*, inner aspect of mandible, *h*, fore leg and *i*, outer aspect of the mandible of *Coptotomus interrogatus?*

glyphics on the disc each side. On the succeeding segments, which are about two thirds as long, there is only one pair of pale submedian dots and these are placed close behind the anterior transverse carina: and there are a few pale markings outside these on each segment, the innermost one of which each side becomes resolved into a single longitudinal dash on the abdominal segments. All these markings disappear on the hindmost segments, which are uniformly deeper brown. The legs are brown with narrow darker lines across the tips of femora and tibiæ. The spiracles are set in the uninterrupted lateral margin of the dorsal shields on the middle abdominal segments.

The basal abdominal segments are of nearly equal length. The length increases slightly successively on segments 4, 5 and 6 and rapidly on 7 and 8, each being one half longer than the segment preceding it. There are a few slender setæ about the lateral margins of all the body segments except the hindmost, and that segment is thickly beset all over its dorsum with short stout spinules. The respiratory tubercle is short and obtusely truncated: viewed from the side it is conspicuously and obliquely prolonged over the bases of the cerci. The cerci are about as long as segments 7 and 8 together, two jointed, the second joint being about three times the length of the basal one: at the tip of the basal segment are two or three slender setæ, and at the tip of the terminal one four more.

2. **Coptotomus longulus** Lec. (supposition). While this study was in progress the larvæ of a second species, so closely similar that it probably belongs in the same genus, were received from Professor T. D. A. Cockerell, collected by him from the Gallinas River, Las Vegas, N. Mexico on the 12th of Jan. 1902. These are like the ones just described in size, and in general coloration, though the color pattern is less sharply defined. They differ in lacking the curved spines from the inner face of the maxilla (Fig. 8, *c*) and in the relative length of the segments of the cerci, the second being hardly twice the length of the first.

3. **Hydroporus undulatus** Say. Length 6 mm.; cerci, 1 mm. additional; greatest width about 1 mm.

Color brown above, whitish beneath. A narrow middorsal line of pale yellow extends from the middle of the head backward the length of the body: it is somewhat interrupted by the dark brown posterior margins of the middle abdominal segments. On the front of the head this pale line is dilated to include three brown spots: a pair of U-shaped spots between the eyes, the arms of the U's extended backward, and a median spot on the base of the rostrum. There is a lateral row of large pale spots beginning on the side of the head, where it encircles the eye, and ending on the eighth abdominal segment. These spots are elongate and jagged on the inner margin on the thoracic segments but rounded and diminishing in size posteriorly on the abdominal segments. The antennæ and legs are pale. In the brown of the rear of the head between the median and lateral spots are three minute yellow dots each side: these are often confluent.

The dorsal plates of all the body segments are thinly clad with slender fragile setæ: the hind margin of each abdominal segment bears a fringe of stouter setæ: the fringe is much shorter than the length of the segment.

The cerci are slender, tapering, longer than the seventh and eighth abdominal segments taken together: they are studded externally with thin and scattering setæ and bear at the tip a little cluster of a few setæ, the central one of which is much stouter than the others and appears as a prolongation, or as a second tapering cercal segment.

The rostrum (Fig. 6) is as long as the head, broad and obtusely rounded at the tip, indented just beyond the middle of each lateral margin, with the broader more flaring edge behind the indentation fringed with excessively minute and slender setæ of which there are several transverse rows that extend across the dorsal surface.

The coxæ are somewhat longer than the femora. The femora, tibiæ and tarsi are armed with stout spinules beneath, and tibiæ and tarsi bear also scanty fringes of longer hairs externally.

The mandibles are long and sickle shaped, and are perforated nearly to the upturned tips, which rest just beneath the tip of the rostrum. Maxillæ greatly reduced, laciniæ and galeæ being wholly wanting (fig. 8 *f*). Labium projecting, mentum narrow, trapezoidal, widened anteriorly, the slender nearly naked two-jointed palpi arising from the square cut front border near the outer angles: at the middle of the terminal joint of palpus are two slender setæ and four or five arise about the base of the first joint.

4. **Bidessus lacustris.** Length 3.5 mm: width .6 mm.

Color grayish brown, faintly marked with grayish yellow, the latter color predominating on the head and on the hinder abdominal segments. Body beneath and all appendages pale. The brown of the head and prothorax forms a large dorsal X whose anterior arms end between and close to the eyes, whose large posterior arms reach backward beyond the middle of the prothorax and are incurved at their tips. Between them arises the stem of a T-mark whose top bar occupies the hind margin of the prothorax. Meso- and meta-thorax with an obscure brown mark each side. Abdominal segments suffused with brownish, and having an indistinct divided pale transverse bar across each except the last.

The respiratory tubercle of the eighth abdominal segment is triangular pyramidal, and continues the slope of the sides of the segment to a subacute tip, and is about half as long as the body of the segment. The cerci are slender and tapering. They are armed with a pair of long setæ externally at one third their length, opposite the tip of the respiratory tubercle, another single external seta at two thirds their length, and at the tip is another external one close beside two internally placed and similar ones, and a central stouter seta that continues the taper of the appendage and is attenuate to an excessively slender tip.

The general pubescence of the body is short, dense and scurfy: that of the legs is shorter and stouter. On the hind borders of the abdominal segments there is hardly any differentiation of apical fringes.

The rostrum is longer than the head, broad and obtusely rounded at its tip, where it bears a fringe of very fine close-set setæ, suddenly broadened opposite the bases of the antennæ where the heavy pubescence of the body begins, and toothed beneath at midway the length of its lateral margins. The mandibles are somewhat constricted just before the tip and bear a ring of scattered setæ about the constriction.

This larva differs from that of Hydroporus most markedly in the dense pubescence of its body, in the possession of longer tarsal claws — claws as long as the tarsus itself, and in the continuity of outline of the sides of the eighth abdominal segment with the respiratory tubercle, there being no constriction setting off the latter at its base.

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